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Yellows, a Non-Infectious Disease of the Progressive Everbearing Strawberry In Montana

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2

MONTANA PROGRESSIVE STRAWBERRY

Since 1938 many seedlings of the Progressive strawberry were raised in connection with an investigation on the cause of yellows in this variety. The most promising of the seedlings which showed high resistance to yellows were tested for productivity, size, quality and marketability of berries. The results were highly satisfactory and the seedling which performed best of all has been released under the name "Montana Progressive."

Montana Progressive has remained free of yellows for seven years and has been in commercial production for three years in the Bitterroot Valley, Montana. It is an everbearing variety, and in yield and quality of berries compares favorably with the Progressive strawberry which was introduced into the Bitterroot Valley about 1915.

DESCRIPTION

The Montana Progressive originated at the Montana Agricultural Experiment Station, Bozeman, Montana, as a seedling from a Progressive and was introduced in 1942.

Plant, medium to large, healthy, somewhat spreading, crown large, good plant maker, very productive, highly resistant to leaf spot and yellows. Plants set in the spring fruit the same year. Foliage, moderately abundant, bright green. Blossoms, perfect and highly resistant to cold. Pubescence on pedicels, abundant and outspreading. Everbearing spring crop fair to good, fall crop heavy. Plants, blossoms, and fruits more or less throughout the season under Montana conditions.

Fruit, medium to large in size, globose to globose-conic to blunt-wedge, slight neck on some fruit, dark to bright red, seeds red, even with surface. Calyx, medium large, reflexed. Flesh tender, pink to reddish in color, subacid. Berries firm, aromatic. Dessert quality good to very good for everbearing variety; shipping quality good.

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INTRODUCTION

Yellows[1] of the Progressive strawberry was first observed in the Bitterroot Valley, Montana about 1925. The disease causes the plant to become yellow in appearance, to decrease in productivity, become short lived and eventually to die. This abnormality has been recorded on other varieties of strawberry for many years and the records indicate that certain varieties have ceased to exist due to the high percentage of yellows occurring in them.

Darrow (7)[2] states, "Sometime between 1915, when healthy plants were seen, and 1920, the foliage of the Columbia strawberry became variegated and the variety soon disappeared from cultivation. Columbia was reported as a cross . . and was introduced in 1906. In 1920 the foliage of Minnesota (originated 1909, introduced 1918) became variegated." He lists 30 varieties or selections, the parentage if known, the year of origin as a seedling, the year of introduction into the trade, and the year variegation was first observed. In addition he cites the observations regarding variegation in other varieties made by other investigators. Among those listed, U. S. D. A. 1818 became variegated after three years from time of origin and Haverland, after fifty years. Yellows in some other varieties of strawberries have been reported and described by various investigators (2, 4, 6, 7, 12, 13, 14, 16, 17, 18).

The Progressive strawberry is a cross, Dunlap x Pan American, made in 1908 by Harlow Rockhill of Conrad, Iowa. It was sent out by him for trial in 1911, and soon became the most popular everbearing variety over a large portion of the northern

[1]The name yellows is commonly used in referring to this condition, and since it is very descriptive of the disease, it will be used in this bulletin.

[2]Numbers in parentheses refer to Literature Cited, p. 10.

half of the United States. It was introduced into the Bitterroot Valley about 1915. The acreage of this berry increased rapidly in Montana until about 1925, when it reached its peak. Largely due to yellows, the Progressive has been grown only to a limited extent since about 1930. Other varieties of everbearing strawberries, such as Gem, Mastodon, Wayzata, Rockhill, etc., were substituted for the Progressive; but because of soil, climate and market conditions, the growers were rather disappointed in returns from these varieties.

An intensive investigation of this disease began in 1934 and the results are reported herein.

SYMPTOMS OF DISEASE

Yellows of the Progressive strawberry manifests itself in the form of interveinal yellowing and sometimes twisting or curling of the leaves. In the majority of cases, this interveinal yellowing is distributed more or less evenly throughout the whole leaf blade, but sometimes it appears to be more pronounced at the edges, producing a marginal effect. In other cases its intensity is not uniformly distributed over the leaf blade, which causes a mottled appearance. A single plant may show one or more than one of these modifications. Plants do not show the same symptoms throughout the season. At one time a plant may show only interveinal yellowing, at another time marginal yellowing may be more conspicuous, or again, it may be practically free of yellowing due to the masking of the yellow color. Affected strawberry leaves are often disfigured, twisted or curled along the midrib. All daughter plants of the diseased mother plant show the symptoms of yellows.

Yellows of Progressive strawberries is most pronounced in the early spring and gradually decreases toward the fall. When yellows is intense, the plants usually die in one or two years. The mortality of plants with marginal yellowing and especially those with mottling is considerably higher than those showing only interveinal yellowing.

EXPERIMENTAL WORK

An intensive investigation of yellows of Progressive strawberries was undertaken in 1934 by the Botany and Bacteriology Department, Montana Agricultural Experiment Station, Bozeman, Montana. The main objectives were (1) to determine the nature of the disease and (2) to develop methods for its control. One hundred and fifty-five plants of Progressive strawberries were brought from the Bitterroot Valley in 1936 and potted in clay pots.

They were kept during the winter in a greenhouse, and in the summer in a nearby garden where the pots were imbedded in soil on a level with the ground. Observations on the intensity and type of yellowing were made and recorded regularly for these plants. At the end of two years, one hundred forty-one plants remained, which represented original plants or their runner (daughter) plants. Of these plants only five, namely 66, 67-1, 68-1, 68-3, and 69-2 remained free of yellowing and therefore could be used as check or healthy plants.

SEED GERMINATION

To determine whether this disease is seed-borne, strawberry seeds were collected in the summer of 1936 from a large number of Progressive plants (table 1), and the seeds of some of these plants were germinated. As a guarantee that no crossing of Progressive plants with other varieties occurred, all mother plants were grown separately from other varieties.

During the fall of 1937 and the winter of 1937-38, many different methods for the germination of the strawberry seeds were tried, all of which gave rather poor results. Finally a method of germinating the seeds was developed which produced good results: clay pots were filled with a mixture of equal amounts of fine sifted soil and of sand; the seeds were scattered on the surface of the soil and lightly covered with very fine sand; the pots were covered with plates of glass to insure high humidity of the soil and air, and water was applied by placing the pots in saucers containing water. The young strawberry plants grew very slowly and many of them died when they were transplanted into small pots.

The results of the germination of strawberry seeds from thirty-one mother plants are presented in table 1. A rather important fact was established at the time of germination of seeds. All seedlings produced from the five healthy mother plants were free of yellows, but many young plants from the other mother plants showed distinct yellows. This indicates that the yellowing factor which is present in plants is transmissible through the seeds. Other investigators (2, 6, 10, 11, 17) have reported seed transmission of similar disease. Table 1 shows a number of healthy and yellow seedlings per each mother plant at the time of potting (May 20, 1938). At this time there were more healthy seedlings than diseased. Table 1 also shows the number of healthy and diseased seedlings as observed during a two-year period, May 1938 to April 1940. The results show that only a few seedlings produced from diseased mother plants remained healthy.

TABLE 1. PLANTS OF PROGRESSIVE STRAWBERRIES PRODUCED BY GERMINATION OF SEEDS PLANTED JANUARY 18, 1938

Straw. Plants	Seeds Planted	CONDITION OF PLANTS						
		At time of potting 5/20/38			April 15, 1940			
*No.	No.	Healthy	Yellows	Total	Healthy	Yellows	Undetermined	Total
2	30							
5	30		1	1		1		1
7	30		1	1		1		1
8	9	3	4	7	1	6		7
9	30	25		25	23	2		25
9A	30							
13	30	2		2		2		2
14	28	8	6	14	2	12		14
16	30	8	9	17	1	16		17
16A	30							
20-2	30	13	6	19	1	18		19
22-2	30	12	4	16		16		16
24	30	5	1	6	2	4		6
25	65	26	2	28	4	24		28
27	30	11	2	13		13		13
31	30	22	1	23	2	21		23
33	30	12	8	20	1	18	1	20
40	30	22	4	26	3	23		26
44	30	25		25	2	16	7	25
53-2	65	35	15	50	11	38	1	50
55-3	30	11	15	26	1	23	2	26
58-3	30	21		21	3	17	1	21
59-3	30	17	2	19		19		19
60-3	30	20	1	21	1	20		21
61-4	30	15	1	16	1	15		16
64-5	30	16		16	4	12		16
66	65	17		17	16			16
67-1	30	19		19	19			19
68-1	65	20		20	20			20
68-3	26	17		17	17			17
69-2	30	9		9	9			9

*Plants from which seed was collected in 1936.

GRAFTS OF RUNNERS OF DISEASED AND HEALTHY PLANTS

During the summer of 1938, many runners were produced on the plants raised from seed, and all runners from healthy plants and those showing typical yellows symptoms from diseased plants were potted for use in experimental work. Since the seedlings from Progressive plants showed symptoms of yellows similar to the mother plant, it was assumed that the plants raised from seed would be satisfactory for transmission experiments.

In the summer of 1938, the runners of the diseased plants produced by germination of seeds of Progressive strawberries were grafted to runners of healthy strawberry plants produced by germination of seeds of Progressive plants: 66, 67-1, 68-1, 68-3, and 69-2. Altogether sixty-four grafts were made and in seven of

them union between diseased and healthy runners was established. These included both contact and tongue grafts. No sign of transmission of yellows was observed on those plants which were used in these seven unions.

The supposition can be made that the progeny of healthy Progressive plants: 66, 67-1, 68-1, 68-3 and 69-2, used for grafting in 1938, are highly resistant or even immune to the disease and therefore no transmission was obtained.

In the fall of 1938, supplies of Marshall plants from Oregon, and Blakemore, and Progressive strawberries from Maryland, were purchased. All these plants were potted in the greenhouse to be used for transmission work. It is known that Marshall plants are especially susceptible to different virus diseases, as demonstrated by the work of other investigators. The Progressive strawberries were bought mainly for a comparison wiith the Progressive plants grown in Montana.

Healthy plants of the Blakemore strawberries and diseased Progressive plants grown from seeds were used for grafting in 1939. Marshall plants did not produce runners during 1939. In the summer of 1939, seventeen grafts were made, thirteen of which produced unions between runners of healthy and diseased plants. In February 1940, when the last readings of these plants were made, no evidence of disease transmission was observed.

In another series one hundred and four grafts were made: runners of forty-six healthy Marshall and fifty-eight healthy Blakemore plants were grafted to runners of diseased plants of the Progressive type. The Marshall plants were grafted early in the spring of 1940 and forty-three unions and three failures resulted. The Blakemore plants were grafted later in the season when the runners were more mature and the result was eleven unions and forty-seven failures. All plants were kept under observation for six months and no transmission of yellows was observed.

During three years, seventy-four unions of runners of diseased (yellows) strawberry plants and healthy plants of the Progressive type, Marshall, or Blakemore were secured; and no signs of transmission were observed during a six-months' period.

This evidence indicates that yellows is not transmitted by grafting diseased and healthy runners. Berkeley (2, 3), Guba (10, 11), Plakidas (17) and Demaree and Darrow (6) failed to secure transmission by runner or by root grafts. By this method some of the virus diseases of strawberries have been transmitted by other investigators.

APHID TRANSMISSION

Transmission experiments with aphids were conducted in the greenhouse in Bozeman in specially built cages. *Capitophorus fragaefolie* Ckll. obtained from Dr. Harold E. Thomas, Berkeley, California, and from Dr. A. A. Granovsky, St. Paul, Minnesota, were used for these transmissions. In making the transmissions, one diseased plant was placed in the cage and infested with healthy aphids. As soon as aphids multiplied sufficiently in number, three healthy plants were placed in this cage and infested with insects from the diseased plant. The plants were kept in the cage for three weeks, after which time they were sprayed with nicotine sulphate to kill the aphids.

In 1938 only two of these experiments were conducted with aphids obtained from Granovsky. In each case, one diseased plant and three healthy plants produced by germination of seeds of Progressive strawberries were used. No sign of transmission of disease was observed on the healthy plants used for these experiments. It was thought that these plants may have been highly resistant to yellows.

During 1939-1940, thirty-six experiments were conducted in an attempt to transmit yellows of Progressive plants to healthy plants of Marshall and Blakemore varieties. Progenies of diseased plants produced by germination of Progressive seeds, thirty-nine diseased Progressive plants brought from the Bitterroot Valley in 1939, and aphids from both sources (Granovsky and Thomas) were used for these transmission experiments.

The last readings were made about June 1, 1940, and not a single plant of either the Marshall (fifty-four plants) or Blakemore (eighteen plants) used for these experiments showed symptoms of yellows.

During three years (1938-1940), six strawberry plants grown from seed of Progressive plants, fifty-four Marshall, and eighteen Blakemore strawberry plants were infested with aphids which had fed upon diseased (yellows) plants. Yellows was not observed on any of the test plants. These results are in agreement with those of other investigators (3, 6, 11, 17).

EFFECT OF SOIL AMENDMENTS ON YELLOWS OF STRAWBERRIES

Experiments were conducted to study the effects on yellows of certain soil amendments. Three hundred diseased (yellows) plants grown from seeds of Progressive strawberry or their runner plants were grown in greenhouse soil. Six 50-plant lots were

treated, respectively, as follows: no treatment (check); 1 gram calcium hydroxide per pot; 1 gram sulphur flour per pot; sprayed with a solution of manganese sulphate 50 p. p. m.; sprayed with a copper sulphate solution 50 p. p. m; sprayed with iron (ferrous) sulphate solution 0.25 per cent. The chemicals in a dry form were applied at monthly intervals for a period of eight months, and the solutions were applied at intervals of two to three weeks. Fifteen applications were made. The first treatment in each case was given on April 18, 1940.

The strawberry plants were kept in the greenhouse until January 1, 1941, when they were put in a cold room for a rest period. At this time no improvement on the yellows condition was observed. The plants were removed from the cold room and placed in the greenhouse April 1, 1941, and kept under observation until December 1, 1941, when the experiment was discontinued. The final reading showed no corrective effect on yellows from any of the treatments. Guba (10, 11) failed to secure any corrective effect on yellows when amendments were added to the soil in which diseased plants were growing.

YELLOWS-FREE STRAWBERRIES

During this investigation many seedlings were raised from seeds of Progressive strawberries (mother plants) brought from the Bitterroot Valley and which had remained free of yellows for two years. Of these, Montana Progressive strawberry (see inside front cover) proved the best in a test for productivity, shape, size, quality and marketability of berries. This selection has remained free of yellows for seven years and has been in commercial production in the Bitterroot Valley for three years. It compares favorably to the Progressive Everbearing Strawberry, which it will probably entirely supplant.

SUMMARY

Yellows, a non-infectious disease of the Progressive strawberry became a limiting factor in the commercial production of this strawberry in the Bitterroot Valley, Montana, about 1925.

Yellows causes the plants to have a yellow appearance, become dwarfed, decrease in productivity, become short-lived, and eventually to die.

Yellows is systemic in nature, as all runners from diseased plants show characteristic symptoms.

Yellows is transmitted through the seed.

Grafting of runners from diseased and healthy plants gave negative results.

Aphids fed on diseased plants and then transferred to healthy plants did not transmit the disease under the conditions of these experiments.

Various amendments added to the soil in which diseased plants were growing produced no effect on yellows.

The experimental results suggest that yellows is genetic in character.

The use of "Montana Progressive" strawberry, produced by the Montana Agricultural Experiment Station, is the only known method of avoiding loss from yellows in the Progressive type of strawberries.

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